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From NBS U.S. Metric Study Interim Rep. 345-9
"Department of Defense"

APPENDIX D

Detailed Advantages and Disadvantages

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Advantages Expected During Transition. The following advantages are those that are peculiar to the transition period. In addition, all of the long-term advantages would be felt in an increasing fashion as transition progresses.

There will be an opportunity to establish standards based on preferred metric sizes.

The need to convert to SI units will give industry and government an unprecedented opportunity to review, correct, and update their documents.

Disadvantages During Transition. During transition the natural problems which evolve with change will occur. Many will subside with familiarity with the particular change. The following are examples of anticipated problem areas:

The psychological resistance of personnel to change could present a formidable obstacle. Few personnel, even engineers and scientists who are well versed in metric units, have the intuitive understanding or "feel" for metric sizes that they have for inch-pound sizes.

Capabilities and readiness will be decreased during the transitional period due to confusion associated with having to operate systems/equipments built to either one measurement system or the other or both. This condition will persist until complete conversion is effected. Conversions should be scheduled by operating unit, so far as possible, rather than by availability of component equipments. Where mixed systems are used, procedures must be developed to minimize error and maintain proficiency. Exercises and drills in making the operationally required conversions must be made a part of the personnel readiness training.

A most significant difficulty will be training and indoctrination of personnel. This is extremely critical in many areas where incomplete indoctrination can have fatal consequences such as safety in operations. From a "training" point of view, the greatest disadvantages will occur during the early stages of transition and require the expenditure of resources (manpower, money, time, and materials) to achieve the same degree of proficiency in the use of metric weights and measures as is now possessed in the use of the inch-pound system. At least three broad categories of training can be identified. A familiarization training program will be presented to all employees through formal training. The second category will be an intensive formal program involving production as well as service group personnel, facility and weapon engineers, laboratory technicians, material personnel and quality assurance personnel. The third will be on-the-job training. The category of training will be based on individual job requirements.

Personnel working with both metric and customary tools and equipment with different measurements will contribute to increased errors.

Technical data will be an impact area because of the need to accommodate the metric system. All manuals, regulations, technical orders, monitors, readouts, meters, maps, blueprints, plans, plant-in-place records, drawings, and other publications and specifications will have to be inspected and changes made on an as required basis.

Within the R&D area, decisions to determine when and how to change over new systems will greatly affect both the cost and time to develop each project. It is anticipated that a development program that was initiated during the middle transition period, 1974-1978, will experience difficulties in both the cost and schedule areas. During this period, the designer will find it difficult to determine the optimum mix of metric and inch-pound specifications required to permit procurement of his design at the minimum cost. During the period 1977-1982, these factors will no doubt increase in complexity. The increasing

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number of SI standards will present the designer with a constantly changing basis for hi designs. He will encounter situations where items specified to an SI standard are not available. These problems will result in many design changes and deviations during the development. Significant additional design effort is anticipated for redesign of certain existing parts, components, and subassemblies that would have been suitable for use in system design in inch-pound system, but are not suitable for use in a metrically designe system. An interface will have to be established and maintained by design personnel an designers, shops, and suppliers so that the designs developed can be produced by availa machine tools and from stock materials whose specifications and availability will also be undergoing change.

The transportation of cargo is based on conventional measurements. Palletizatio containerization, and standard loading systems are all interfaced and must be maintaine compatible. Further, the air cargo operation directly interfaces with surface and sea systems and compatibility must also be maintained. Widespread adoption of the metric system will require metric orientation guides, guidance, and instructions for use of shipping and transport personnel. The movement of materials is controlled by the volum shape, and weight of the item to be transported. Conversion tables and modified measuring equipment (scales, etc.) will be required. Rapid response containerized distribution envisions the interaction of containers, materials handling equipment, trans portation equipment and documentation. Trends and efforts toward standardization of van type containers will require consideration of compatibility with carrier equipment and distribution methodology. A variety of specialized types of containers are already in existence. However, conversion of current or future containers to new dimensions to co ply with a new metric system standard is not considered technically or economically justi at this time. For example, freight van containers are built in the United States to confor to standards adopted by the USASI (United States of America Standards Institute), with abo seventy percent of the member bodies of the ISO (International Standards Organization) having approved the USASI standards.

Depot maintenance operations will require more time and material during the transition period. Field maintenance organizations must solve the problem of transportin the extra equipment and material which the metrication process will impose. The maintenance section of an armored cavalry squadron, for example, currently has a prescribed load list (PLL) of 466 line items. When the squadron goes to the field, the maintenance section must carry the PLL plus all of its other equipment and tools in organic transporta This transport is already overcrowded and the addition of 25-50% more to the PLL due to dual part stockage and dual tool sets will further compound this problem.

There will be a need for dual common tools and special precautions will have to be taken to prevent mixing of common hardware and tools. It can be anticipated that there will be some increase in damage caused by maintenance technicians due to inadvertent mixing of inch and metric parts and tools. In some cases additional shop space will be required for maintaining equipment in both systems especially when separate metric and nonmetric operations must be maintained.

Metalworking equipment (machine tools) for the most part has a long life span. Some of the items in use today are over 35 years old and still operating. The Defense Industrial Plant Equipment Center reports that the DOD has 144,122 machine tools in the DIPEC inventory which had an original acquisition cost of approximately $2.4 billion. Studies indicate that modification of the inventory would cost approximately $115 million. Gauges, markings, and dials on 95 percent of this equipment are graduated in the inch-pound system. Inch-pound and metric machine tools are generally capable of producing

mponents dimensioned in either system of units provided the operator has the necessary measuring equipment. The major exceptions are screw threads, gears, and splines. Conversion of the feed mechanisms to enable a machine tool to be used under the metric system could be achieved in two ways. The first, and usually more expensive method would be to replace the feed screw and nut assemblies of the machine with units having metric pitch. The alternative method would be to replace or add to the inch-pound reading indicator one engraved in metric units.

There will be an increase in Federal Stock numbers due to dual part stockage. Estimates for this increase range from a peak of 18% to 50%. Parts interchangeability and shortages of metric material, particularly in the early conversion period, will be a problem. There will be some requirements for more storage space, and perhaps a need to separate common items.

Metrication will, in the early phases, result in considerable confusion when attempting to secure quotations for supply, services, and equipment. Additional management effort will be required specifically for planning and phasing the production and procurement of metric components. There will be some increase in acquisition and development time, primarily due to gathering metric information, and preparing drawings with metric or dual dimensions. Further, there will be a requirement for dual specifications, a need to update technical documentation and an increase in the number of engineering changes. The procurement of off-the-shelf bits and pieces poses a peculiar conversion problem.

The majority of the dollar costs previously discussed in the report under Sec IV A., Added Cost to Maintain Constant Mission Capability, will occur during this period. In addition to cost, time delays will also be encountered in the system acquisition area.

During the transition period, conversion to SI will result in a major increase in complexity of industrial readiness planning. Industrial readiness planning will have to be continuously updated as the conversion to SI proceeds. To maintain industrial readiness during periods of hostilities or other military commitments, plans will have to be developed so that production capability under the present system will not be lost until adequate capability is assured under the metric system.

Computer programs for data systems will have to be revised. For example, tactical data systems operating as an entity will require simultaneous conversion of all units if they are to retain their usefulness. Present gun and missile fire control computers are of the analog type, except for some very recent systems which are digital. Analog synchro data transmission systems are used with the analog computers. Sensors such as fire-control radars and optical rangefinders provide analog data readouts. All of these elements of the fire control systems (computers, transmission systems, and sensors) are calibrated in other than SI units. There is no simple and inexpensive way to convert analog fire control systems to SI units.

New equipment will be designed and constructed using SI units of measurement while other equipments which were designed and constructed using inch-pound units of measurement are still in service. This means that the DOD will be operating mixed equipment for an indefinite period. Under these circumstances, the possibility of maintenance errors will increase through greater exposure to unintentional use of improper tools, parts, instruments, and calibrations. It will be necessary to train maintenance personnel in the use of both measurement systems to counteract possible confusion and a greater possibility of error. Once the change to the metric system of measurements is accomplished, the international cross servicing and maintenance of systems will be less susceptible to error.

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Installed and support equipment in operational systems may require modifications to maintain system compatibility during the conversion process.

Communications procedures pertaining to weather, navigation, and takeoff/landing instructions will have to be revised to accommodate the change.

Observations and weather reports will have to be changed to reflect metric measu for ceilings, visibilities, altitudes, and windspeeds.

Long-term Advantages.

The establishment of a worldwide standard of weights and measures will facilitate the interchange of ideas, technology, data, etc. Acceptance of the International System of Units (SI) will contribute to the establishment of a worldwide standard for measurements. This will allow elimination of multiple systems of units and will eliminate the necessity fo the time-consuming conversion required to transfer from one system of units to another. Several of the advantages which will accrue to the DOD are listed below.

There will be the potential advantage of worldwide compatibility in every phase of operations.

Commonality of items and systems between U.S. and foreign nations will expedite repairs on inoperative equipment, thus providing possible support in areas where support is now nonexistent.

An increased potential for international standardization will result in the necessity to procure, handle, stock, distribute, operate, and maintain fewer systems/equipments and thus reduce the expenditure of resources.

Metrication will make our measurement system more compatible with that of our Allies worldwide. This will provide for easier and better interface between our weapons systems and those of our allies. Exchange of information will also be expedited by simplifying the understanding of all data including design, operations, and training.

Acceptance of the metric units will provide a simplicity not inherent in the inch-pound system or similar systems of units which do not have a base of 10. It will eliminate the current hybrid mix of units now used throughout the various technologies. There is only one definition and one name for each unit (in the inch-pound system, for example, there are different sized "ounces" and "pounds" depending upon whether Troy weight or Avoirdupois weight is being utilized); the units in other systems have a mixed relationship to each other (e.g., inches - feet - yards - rods - miles) but the SI units are related by factors of 10. As a result, complex conversion factors are not required for calculations. Calculations will be in the simplest form possible (e.g., no complex conversion factor will be needed to convert meters to millimeters, which is not the case, for example, in convert rods to inches and will be performed with ease and less error).

Favorable results from standardization on metric units of measurement can provide impetus for standardization of hardware.

Metrication will provide potential advantage in standardization and worldwide availability of standard packages, parts and equipment procured through the local purchase sources.

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Metrication will reduce the total training time required to teach and indoctrinate mechanics, engineers, and others.

The chance for error in computations will be greatly reduced when the metric system is fully implemented. Compatibility will be achieved among range instrumentation, scientific measuring devices, and engineering units.

A general modernization and updating of individual plant equipment, ground equipment, and shop hand tools can be expected upon converting to the metric system.

Savings will be realized in automatic data processing time as a result of fewer conversions and simpler programming.

Long-term Disadvantages.

The completion of metrication will leave some long-term disadvantages. Those that will occur deal with long life items which will remain in inventory well after the programmed transition. These include:

There will be difficulty experienced in retaining material and manpower for the maintenance, modification or activation of existing long-life systems, equipments and facilities.

Dual (inch-pound and metric) ranges of material and support equipment will have to be maintained in inventory in varying quantities for a period approaching thirty years.

Due to smaller production runs, there will be an increasingly greater cost of material produced under the inch-pound system for the maintenance, modification or activation of systems, equipments and facilities.

There will be a continuing need for the training of personnel in the use of inch-pound systems.

There could be a forced obsolescence of productive, useful and otherwise satisfactory material.

There could be a loss of skilled manpower due to the inability to train existing skilled technicians to an equal degree of proficiency in the use of the metric system.

Prepositioned equipment may need conversion before being activated.

functions of the U.S. Coast Guard with respect to shipbuilding (verification of compliance with safety and other standards), and the area of automobile safety. In the latter case the influx of metric-dimensioned foreign vehicles and components is requiring special tools for servicing and special blueprints for safety standards. Slightly over one-third of the 57 agency responses[4] in the "area of national responsibility" part of the Survey expect increasing measurement-related problems, which, in the absence of a concerted national metrication effort, will range up to substantial or serious with regard to their area of responsibility.

Of these 57 agency respondents, 28 see U.S. metrication facilitating the activities within their areas of responsibility and their interactions therewith, 31 favor increased U.S. metrication (most endorsing a coordinated national program), and only one opposes any national program.

CONCLUSION

Thus, the Survey of Federal Government Agencies found substantial expectation of increasing problems in the Federal Establishment with continuation of a *laissez faire* policy toward metrication, and widespread feeling that a coordinated national effort to increase the use of SI measurement units and engineering standards in the U.S. is desirable. A broad consensus of the Federal agencies and responding subunits expect that the long-term advantages of such a move would clearly outweigh any short-term disadvantages, even including the substantial costs that would be involved during the conversion period.

[4] Some agencies were asked for responses on several "areas of national responsibility" and some agencies were not asked for responses. Thus, the number of inputs to this part of the survey does not equate to the overall number of agencies covered.

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